

SMITH

The Nutritive Value of Corn of different
Protein content when fed to Swine

Animal Husbandry

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THE NUTRITIVE VALUE OF CORN OF DIFFERENT
PROTEIN CONTENT WHEN FED TO SWINE

BY

WILLIAM HERSCHEL SMITH

B. S. University of Nebraska, 1906

THESIS

Submitted in Partial Fulfillment of the Requirements for the

Degree of

MASTER OF SCIENCE

IN ANIMAL HUSBANDRY

IN

THE GRADUATE SCHOOL

OF THE

UNIVERSITY OF ILLINOIS

1912

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UNIVERSITY OF ILLINOIS
THE GRADUATE SCHOOL

May 21, 1912.

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

William Herschel Smith

ENTITLED The nutritive value of corn of different protein
content when fed to swine.

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Master of science in Animal Husbandry.

H. S. Grindley.
In Charge of Major Work
Robert W. Mumford
Head of Department

Recommendation concurred in:

Committee

on . . .

Final Examination



THE NUTRITIVE VALUE OF CORN OF DIFFERENT PROTEIN CONTENT
WHEN FED TO SWINE.

From the available published data it is quite evident that little has been done in this country in making a study of the nutritive value of feeding stuffs for swine. For example, with corn, which is the most common feed for swine, there are only three experiments reported relating to the digestibility of the nutrients and none comparing the relative value of corn containing different percentages of protein. In fact, from the compilation made by Lindsey, Kellner, Henry, and others it would appear that less had been done in determining the digestibility of feeding stuffs with swine than with any of the other farm animals. It was thought, therefore, that a study relative to the nutritive value of common corn in comparison with high and low protein corn when fed to swine would be of value.

In 1886¹ Jordan , of the Maine Experiment Station, made the first report of a digestion experiment in which corn in different forms was fed to swine. A boar pig, weighing 50 pounds, was used in this experiment and in each case the feeding period covered 12 days, 7 of which formed the preliminary and five the test period.

These results showed that the coefficient of digestibility of protein in shelled corn was 69 percent, for corn and cob meal 76 percent and for corn-meal 86.1 percent. The composition of the corn meal was dry matter 81.25 percent and protein 8.25 percent.

In 1893² Snyder carried on an experiment with a mature Yorkshire, Berkshire, Duroc Jersey barrow, which covered two periods of 3 and 4 days each, during which time the pig received ground corn. The composition of the corn

¹ Maine Agricultural Experiment Station Report 1885-86

² Bulletin 26, Maine Agricultural Experiment Station.

and the digestibility of the protein was as follows: dry matter 88.27 percent, protein 11.25 percent, coefficient of digestibility of protein 89.9 percent.

Some unpublished data of two experiments conducted by Dietrich, in conjunction with the Laboratory of Physiological Chemistry of this department showed the following results: in 1906 an experiment with two mature barrows, a Berkshire and a large Yorkshire showed the coefficient of digestibility of protein to be 82.06 percent and 78.81 percent respectively, or an average of 80.44 percent. The composition of the corn fed was, dry matter 86.38 percent and protein 9.8 percent. In 1907 a similar experiment with two mature Berkshire barrows showed the digestibility of protein to be 80.48 percent with one, and 75.89 percent with the other, or an average of 78.18 percent. In this case the corn had 86.6 percent dry matter and 8.69 percent protein.

In 1910, ¹Michael and Kennedy conducted an experiment to compare the digestibility of ground corn with that of ground corn and stock food. Twelve pigs, each weighing approximately 160 pounds, were fed in digestion cages 10 days. The last seven days were taken for the test periods. The average composition of the corn fed was dry matter 87.27 percent and protein 9.29 percent. The coefficient of digestibility of the protein of the corn varied from 78.16 percent to 83.58 percent, averaging 81.33 percent.

As to the second point, namely, the digestibility of corn with different protein content, ²Hopkins and ³Smith, of this station, have found that through selection it is possible to produce from a single variety, two strains of corn, one of which contains more than half again as much protein as the other, as the following table shows:

¹Bulletin 113, Iowa Agricultural Experiment Station.

²Bulletin 129, Illinois Agricultural Experiment Station.

³American Breeders Magazine, Vol. 1, 1910.

Year.	Average of High Protein in per-cent.	Average of Low Protein in per-cent.	Differences between Crops.
1896	10.92	10.02	.00
1897	11.10	10.55	.55
1898	11.05	10.55	.50
1899	11.46	9.86	1.60
1900	12.32	9.34	2.98
1901	14.12	10.04	4.08
1902	12.34	8.82	4.12
1903	13.04	8.62	4.44
1904	15.03	9.27	5.76
1905	14.72	8.57	6.15
1906	14.26	8.64	5.62
1907	13.89	7.32	6.57
1908	13.94	8.96	8.96
1909	13.41	7.65	7.65
1910	14.87	8.25	8.25
1911	13.78	7.89	7.89

GENERAL PLAN.

The general plan of this experiment was to select four hogs, all of which were practically mature and comparable from the standpoint of quality, conformation, and previous care and development.

They were placed in digestion crates and fed a sufficient length of time to accustom them to this treatment before the test periods began. The four pigs were fed common corn during the first test period and later two of them were fed high protein corn and the other two low protein corn during the second test period. Accurate accounts were kept of the feeds consumed and feces excreted from which the coefficient of digestibility of each kind of corn was determined.

EXPERIMENTAL.

Animals used. The four barrows selected for this experiment were 9 months of age. Two were pure bred Tanworths, litter mates, and two were Duroc

Tamworth cross. From the time of farrowing, all of these pigs had received the same feed and care, having been used in another feeding experiment.

The two Tamworths designated as Nos. 1 and 3, weighed 280.5 pounds, and 282 pounds respectively, and were almost identical in conformation. The two Duroc-Tamworth pigs, Nos. 2 and 4, were also of similar conformation but differed slightly in weight, one weighing 256.5 and the other 236.5 pounds. The four pigs, aside from breed type, were very similar as the cut shows.



No. 1. Tamworth.

No. 4. Duroc.



No. 2. Duroc.

No. 3. Tamworth.

Feeds. The feeds used in this experiment were obtained from the 1910 crop raised by the Agronomy Department of this university. They are designated throughout the experiment as A, B, and C. Feed A was common white corn, Feed B was white corn from the crop which had been selected and grown for low protein content, Feed C was corn from the high protein crop. Considerable difference was observed in the physical properties of the two samples of corn B and C. The ears of corn B were larger with large, soft kernels, while those of corn C were small and the kernels hard and flinty.

Feeding and General Care of the Animals. The experiment began May 9th, 1911, when the pigs were put into digestion crates and kept there until June 22nd. The crates were constructed so that a hog could lie down comfortably but could not turn around in them. This, of course, prevented any chance for exercise in the crates, hence it took some time to get the pigs accustomed to this mode of living. To keep the pigs in as normal a condition as possible they were taken out of their crates twice daily and exercised in a paved lot. It was noticed that after the pigs became accustomed to their crates they were just as well satisfied in them as outside.

The pigs were fed twice daily, morning and evening. The feed was carefully weighed and given to them in the form of slop in a metal pan which was constructed so as to prevent the loss of feed. Throughout the experiment each pig was given all the corn he would clean up readily and all the water he would drink. The corn was ground. In case any of the feed was refused, it was weighed back so that an exact record was kept of the feed actually consumed.

The pigs were fed forty-five days, from May 9th, to June 22nd. The feeding was divided into four periods as follows: May 9th to June 1st, preliminary period of 24 days; June 1st to 8th, test period No. I, 7 days;

June 8th to 15th, transitional period, 7 days; and June 15th to 22nd, test period No. II, 7 days. When the pigs were first put into the crates they were given a very light feed, one half pound of corn per pig per day. This was all they would eat at the start under this new mode of living. As they became more accustomed to this treatment their feed was gradually increased. During the preliminary period when the pigs were getting accustomed to their new conditions and during the test period No. I, the four pigs were fed Corn A, the common corn. Then followed the transitional period. The feed at this time was changed, Pig 1, Tamworth, and Pig 4, Duroc, were given a ration from Corn C, the high protein corn, and Pig 2, Duroc, and Pig 3, Tamworth, were given a ration of Corn B, the low protein corn. After a week of this feeding, test period No. II began.

Collection of Feces. The feces from each pig were collected twice daily during periods I and II in the following manner: when the pigs were taken out of their crates for exercise they were driven into a small pen. There they dropped their feces, which were either caught in tin pails or allowed to drop on a clean paved floor. In the latter case, the feces were easily collected without waste. Not once during the entire experiment did a pig drop feces in its crate.

The feces were weighed carefully each day and placed in an air tight pail which had been previously washed with a 10 percent solution of thymol. The samples were then placed in cold storage. At the end of each of the seven day test periods a composite sample was taken, weighed, and placed in an electric oven at a temperature of 55 to 60 degrees Centigrade for several days to air dry. It was again weighed, sealed in an air-tight vessel and stored until ready to analyze.

Chemical Analysis.

The feeds and feces were analyzed chemically to determine the total nitrogen and moisture content. This work was done by the writer in the Laboratory of Physiological Chemistry of this department. The following methods were used:

(a) Total Nitrogen. The sample was ground in a dung mill until it would pass through a millimeter sieve and thoroughly mixed. About 1 gram sample of the material was weighed in triplicate and transferred to Kjeldahl flasks by the use of ashless filter papers, the nitrogen of which has been determined. The sample in the flask was treated with 25 cc of concentrated sulphuric acid, the nitrogen factor of which had been determined. The contents were heated gently on the digester until the frothing ceased. It was then cooled and 5 grams of powdered potassium sulphate and .7 grams of mercury added and the mixture again heated until the liquid became clear. After cooling, the sides and neck of the flask were washed down with ammonia-free distilled water and the contents boiled for one and one-half hours. The contents were allowed to cool and 250 cc of ammonia-free distilled water and a small portion of ignited pumice stone, also 80 cc of a mixture of sodium hydroxide and potassium sulphide (600 grams of Greenbank's alkali and 12.5 grams of potassium sulphide per liter of water) were added. The flasks were then connected with the condensers and heated and adjusted so that approximately 200 cc of the distillate came over in about 40 minutes. The excess of acid was then titrated with the standard alkali, using Congo Red as the indicator. From these data the calculation was made for the amount of nitrogen.

(b) Moisture. About 5 grams of the material were weighed in triplicate into lead dishes with covers. These were placed in a steam oven at a temperature of 102 degrees Centigrade for a period of 4 hours. They were then removed, placed in dessicators, cooled and weighed. This method was

repeated until the sample became constant in weight.

DISCUSSION.

The experimental data include the chemical composition of the feeds and feces, also the weight of the feed offered and the digestibility of the nitrogen of the different feeds.

Chemical Composition of the Feeds. In the determination of the chemical composition of feeds only the moisture and nitrogen were found, the protein being obtained by multiplying the nitrogen by 6.25.

Table 1: Chemical Composition of Feeds. Expressed in percent of fresh substance.

Corn .			Chemical Composition.		
Sample	Kind	Physical Condition	Dry Matter	Nitrogen	Protein(N.X 6.25)
A	Common	Normal	88.72	1.8178	11.36
B	Low Protein	Hard and Flinty	88.31	1.6332	10.20
C	High Protein	Medium Hard	88.58	1.8856	11.78

The data show the percent of dry matter in the three kinds of corn to be practically the same. A difference of 0.41 percent between Corn B and A, and a difference of 0.27 percent between Corn B and C, and a difference of only 0.14 percent between Corn C and A, are no more than might be expected between the three samples of corn. The main difference in the corn is the amount of protein present, Corn A having 11.36 percent, Corn B 10.20 percent, and Corn C 11.78 percent. Corn A, the common white corn, had a higher percentage of protein than is usually found in corn, yet it is 0.47 percent lower in protein than Corn C, the high protein. Corn B, the low protein corn, had 1.58 percent less protein than Corn C, and 1.16 percent less than Corn A. These results show that there was much less difference between

the percentages of protein than was expected. Referring to the table on page 3, it will be seen that the results of the analysis of the selected ears for the crop of 1910 were 14.87 percent for high protein corn, and 8.25 percent for the low protein corn. The samples used in this investigation compare more closely to those of 1899 when the values were 11.46 percent for the high protein corn and 9.86 percent for the low. However, the corn used in this investigation was a composite sample taken from the cribs after it had been stored several months and in this the method differs from that used by the Agronomy Department where they analyzed only a certain number of selected ears.

Amount of feed Consumed per Week. It will be of interest to study the data showing the amount of corn consumed by each pig during the different periods of the experiment. These results are presented in the following tables, Nos. 2 to 6.

Table 2: Amount of Feed Consumed During Period I , June 1st to 8th. (Expressed in pounds.)

---Pigs----		Corn Fed.	Day of Week.							-Total Fed per Week.-	
No.	Breed.		1.	2.	3.	4.	5.	6.	7.	Per Pig.	Per 100 lbs. Live Weight.
1.	Tamworth	A	3.50	3.50	3.50	3.50	3.50	3.50	3.50	24.5	8.56
2.	Duroc	A	3.50	3.50	3.50	3.50	3.50	3.50	3.50	24.5	9.28
3.	Tamworth	A	3.50	3.50	3.50	3.20	2.88	2.88	2.80	22.3	7.90
4.	Duroc	A	2.75	3.00	3.00	2.50	2.75	2.38	2.62	19.0	7.82

During the preliminary period, pigs. 3 and 4 did not take to their feed as fast as pigs 1 and 2, and from the above table it will be observed that pigs 1 and 2 during Period No. I ate 24.5 pounds for the week, while pig 3 ate only 22.26 pounds, and pig 4, 19 pounds. Calculating on the basis of live weight, the same comparative difference holds true. Pig 1 ate 8.56 pounds of feed per hundred pounds of live weight; pig 2, 9.28 pounds; pig 3, 7.90 pounds; and pig 4, 7.82 pounds. During this period each animal seemed to be in good

physical condition and contented in its crate.

Table 3: Amount of Feed Consumed During the Transitional Period,
June 8th to 15th.

(Expressed in pounds.)

Pigs.		Corn Fed.	Day of Week.							Total Fed per Week.	
No.	Breed.		1.	2.	3.	4.	5.	6.	7.	Per Pig.	Per 100 lbs. Live Weight.
1.	Tamworth	C	3.50	3.50	3.50	3.50	3.50	3.50	3.50	24.50	8.45
2.	Duroc	B	1.50	2.00	2.00	2.00	2.00	2.00	2.00	13.50	5.05
3.	Tamworth	B	2.00	2.00	2.00	2.00	2.00	2.00	2.00	14.00	4.94
4.	Duroc	C	2.00	2.00	2.00	2.00	2.00	2.00	2.00	14.00	5.73

At the beginning of the transitional period the four pigs were divided into two lots of two each. Pig 1, Tamworth, and 2, Duroc, were in practically the same condition but slightly better than 3, Tamworth, and 4, Duroc, which were alike. Therefore, in order to make the two lots comparable from the standpoint of condition and breed Pigs 1 and 4 were put into Lot I and pigs 2 and 3 in Lot II. The pigs in Lot I were fed the high protein corn and those of Lot II, the low protein corn.

The same amount of feed that they had been consuming at the end of Period I was offered them at the beginning of the transitional period when the feed was changed from Corn A to Corn B, for Pigs 2 and 3, and to Corn C, for Pigs 1 and 4. From the data in Table 3 it will be seen that Pig. 1, given Corn C continued to eat this same amount of corn until the end of the period, Pig 2 given corn B, immediately went off feed and ate 1.5 pounds the first day and only 2 pounds per day during the remainder of the transitional period, Pig 3 and 4 also refused to eat as much as formerly but the greatest difference was with Pigs. 2 and 3, which were changed to a ration of Corn B, the low protein feed. Pig 2 ate 11 pounds of feed less than during period I, or a difference of 4.23 pounds per hundred pounds of live weight, and Pig 3 ate 8.26 pounds less or a

difference of 2.96 pounds per hundred weight.

Table 4: Feed Consumed During Period II, June 15th to 22nd.

(Expressed in pounds.)

Pigs.		Corn Fed.	Day of Week.							Total Fed per Week.	
No.	Breed.		1.	2.	3.	4.	5.	6.	7.	Per Pig.	Per 100 lbs. Live Weight.
1.	Tamworth	C	3.50	3.50	3.50	3.50	3.50	3.50	3.50	24.50	8.42
2.	Duroc	B	2.25	2.50	2.50	3.00	3.00	3.00	3.00	19.25	7.26
3.	Tamworth	B	2.00	2.25	2.50	3.00	3.00	2.90	2.90	18.55	6.60
4.	Duroc	C	2.00	2.25	2.50	3.00	3.00	2.82	2.82	18.39	7.63

The above table shows the amount of feed consumed per pig during period II. It will be noted from this data that Pigs 2 and 3 gradually came back on their feed. The amount consumed increased as they became accustomed to their feeds so that by the end of the week they were eating practically the same quantity of corn B as they had of Corn A. The feed seemed to become more palatable.

To obtain a clearer idea of the feed consumed by each pig during Periods I and II, the data are given in the following table.

Table 5: Average Amount of Corn Consumed During Periods I and II.

(Expressed in pounds.)

Pigs.		Period I June 1st to 8th.										
No.	Breed.	Corn Fed.	Feed Consumed per Pig.	Feed Consumed per 100 lbs. live Weight.	Amount Feed Consumed per Day.	Corn Fed.	Feed Consumed per Pig.	Feed Consumed per 100 lbs. Live Weight.	Amount Feed Consumed per Day.	In Feed Consumed per Pig.	In Feed Consumed per 100 W't.	In Amount Feed Consumed per Day.
1.	Tam	A	24.50	8.56	3.50	C	24.50	8.42	3.50	0.00	0.14	0.00
2.	Dur.	A	24.50	9.28	3.50	B	19.25	7.26	2.75	5.25	2.02	0.75
3.	Tam.	A	22.26	7.90	3.18	B	18.55	6.60	2.65	3.71	1.30	0.53
4.	Dur	A	19.00	7.82	2.71	C	18.39	7.63	2.63	0.61	0.19	0.08

The above table shows the amount of Corn A consumed per pig during Period I, as compared with B and C during Period II. It will be noted that, Pig 1, consumed the same amount of Corn A as Corn C, that Pig 2, consumed on an average 2.75 pounds of Corn B daily as compared to 3.5 pounds of Corn A, that Pig 3 ate on an average 2.65 pounds of Corn B as compared with 3.18 pounds of Corn A, and that Pig 4 ate on an average of 2.63 pounds of Corn C daily as compared to 2.71 pounds of Corn A.

These results show that the differences in total feed consumed per pig and the amount per hundred pounds live weight were considerably greater when the change was made from Corn A to Corn B, than when the change was made to Corn C. In case of Pig 4 we find it ate only 0.61 pounds less during Period II than during Period I, and that Pig 1 was able to eat the same amount in both periods. On the other hand, Pigs 2 and 3 ate 5.25 and 3.71 pounds respectively less of Corn B, showing that Corn C, the high protein corn was apparently much more palatable than the low protein corn. This difference in the consumption may be due to the physical properties of the two kinds of corn, namely, that the high protein corn was much harder and flintier than the low protein corn.

Weight and Composition of the Feces. Having discussed the data relative to the composition and amount of corn consumed by each pig during the different periods, the following results have to deal with the amount and chemical composition of the feces. The weights of the dung are calculated on the basis of the total amounts excreted per pig, also per hundred pounds live weight, and per pound of corn consumed.

Table 6: Weight of the Fresh Feces for Period I, June 1st to 8th.

Pigs.		Corn Fed.	Day of Week.							Total Feces.		
No.	Breed.		1.	2.	3.	4.	5.	6.	7.	Per Pig lbs.	Per 100 lbs. Live W't.	Per lb. of Corn Fed.
			grams	grams	grams	grams	grams	grams	grams			
1.	Tam.	A	494.5	277.8	540.0	539.0	469.0	547.2	570.0	7.58	2.65	0.31
2.	Dur.	A	285.8	462.7	525.0	373.0	401.0	486.0	488.5	6.66	2.48	0.27
3.	Tam.	A	512.6	358.4	420.0	361.5	354.5	349.0	399.0	6.07	2.15	0.27
4.	Dur.	A	694.0	181.5	505.0	304.5	00.0	336.0	571.0	5.71	2.35	0.30

The above figures show that during Period I, Pig 1 excreted 7.58 pounds of feces, Pig 2, 6.66 pounds, Pig 3, 6.07 pounds, and Pig 4, 5.71 pounds. Referring to Table 2, we find that Pigs. 1 and 2 ate 24.50 pounds of corn each during this period and that Pig 3 ate 22.26 pounds, and Pig 4, 19 pounds. This shows that the amount of feces voided was in proportion to the amount of feed eaten. Calculating on the basis of live weight we find that each pig excreted practically the same amount of feces. Pig 1, excreted 2.65 pounds per 100 lbs. live weight, Pig 2, 2.48, Pig 3, 2.15, and Pig 4, 2.35 pounds. The amount excreted per pound of corn fed was as follows: Pig 1, 0.31 pounds, Pig 2, 0.27 pounds, Pig 3, 0.27 pounds and Pig 4, 0.30 pounds. Each pig was very regular in dropping its feces except Pig 4. Pigs 1, 2, and 3 dropped their feces twice each day regularly, but Pig 4 missed once on the second and twice on the fifth day of this period, No. I.

Table 7: Weight of the Fresh Feces for Period II. June 15th to 22nd.

Pigs.		Corn Fed.	Day of Week.							Total Feces.		
No.	Breed.		1.	2.	3.	4.	5.	6.	7.	Per Pig lbs.	Per 100 lbs. Live W't.	Per lb. of Corn Fed.
			grams	grams	grams	grams	grams	grams	grams			
1.	Tam	C	572.6	606.0	609.7	608.5	541.8	519.8	579.5	8.88	3.06	0.36
2.	Dur.	B	339.0	394.8	388.5	392.7	415.5	454.3	596.4	6.57	2.48	0.34
3.	Tam.	B	385.5	364.2	403.4	304.2	463.5	182.6	255.5	5.20	1.85	0.28
4.	Dur.	C	283.7	367.2	283.1	337.0	544.0	287.3	267.2	5.22	2.16	0.28

From the above figures we find that the amount of feces excreted per pig was in proportion to the feed eaten, as was the case in Period I. There was considerable difference between the animals in the amount excreted per 100 pounds of live weight. Referring to Table 6, page 13, we note that the greatest variation in Period I was from 2.15 pounds in case of Pig 3, to 2.65 pounds with Pig 1, while in Period II the variation with the same pigs was from 1.85 pounds with Pig 3 to 3.06 pounds with Pig. 1. Further, there was a greater variation in the weight of the total feces than in the case of Period I, varying from 5.22 for Pig 4, to 8.88 pounds for Pig 1. The difference in the data for this period, No. II does not seem to have any relation to the nature of the corn, either the protein content or the physical condition.

Chemical Composition of the Feces: In determining the chemical composition of the feces, only the moisture and nitrogen were determined, the protein being obtained by multiplying the nitrogen by 6.25.

Table 8: Composition of Feces for Periods I and II.

(Expressed in percent of fresh and water-free substances.)

Pigs.		Corn Fed.	Fresh Substance			Water-free Substance.	
No.	Breed.		Dry Matter	Nitrogen	Protein (N x 6.25)	Nitrogen	Protein. (N x 6.25)
Period I. June 1st to 8th.							
1.	Tam.	A.	93.77	1.9454	12.16	2.074	12.96
2.	Dur	A	94.89	2.5264	15.79	2.662	16.64
3.	Tam.	A	94.58	1.9186	11.99	2.028	12.67
4.	Dur.	A	91.56	2.1344	13.34	2.331	14.57
Ave	All	A	93.82	2.1312	13.32	2.274	14.21
Ave	1&3	A	94.17	1.932	12.07	2.051	13.76
Ave.	2&4	A	93.44	2.3304	14.56	2.496	15.60
Period II June 15th to 22nd.							
1.	Tam.	C	92.60	2.0082	12.55	2.168	13.55
2.	Dur.	B	93.79	2.6553	16.59	2.831	17.69
3.	Tam.	B	92.30	2.4236	15.15	2.625	16.41
4.	Dur.	C	92.66	1.8688	11.68	2.016	12.60
Ave.	1&4	C	92.63	1.9385	12.11	2.092	13.07
Ave.	2&3	B	93.04	2.5394	15.87	2.728	17.05

The above table shows the composition of the feces during Periods I and II on the fresh and water-free basis.

On the basis of fresh substance we note that the variation of dry matter in Period I was from 91.56 percent in case of Pig 4 to 94.89 percent in case of Pig. 2. Pigs 1 and 4, both Tamworths, have practically the same amount of dry matter 93.77 percent and 94.58 percent respectively. The average for all the pigs was 93.82 percent. The percent of nitrogen with the Tamworths, Pigs 1 and 3, is in both cases less than that of the Durocs, Pigs 2 and 4.

The above results for Period I when each pig received feed A, common corn, shows that the percentage of nitrogen in the feces on the water-free basis was as follows: Pig 1, 2.074; Pig 2, 2.662; Pig 3, 2.028; and Pig 4, 2.331. These figures indicate a difference of 0.04 percent between the values for Pigs 1 and 3, and of 0.33 percent between those for Pigs. 1 and 4. Comparing the Tamworth pigs Nos. 1 and 3, with the two Durocs, Nos. 2 and 4, we find the latter contained more nitrogen, 2.05 and 2.49 percent respectively with a difference of 0.44 percent. This suggests that the breed in this particular case was a greater factor than the individuality.

The results for Period II when Pigs 1 and 4 were fed Feed C, high protein corn, and Pigs 2 and 3, Feed B, low protein corn, show that the percent of undigested nitrogen was, for Pig 1, 2.168; for Pig 2, 2.831; for Pig 3, 2.625; and for Pig 4, 2.016. In this case, not considering the individuality or breed of the pigs, but the differences in the feeds used, we find that the average undigested nitrogen in the feces from the pigs fed Feed C, high protein corn, was 2.09 percent, and the pigs fed Feed B, low protein corn, was 2.73 percent, making a difference of 0.64 percent. In other words, the undigested nitrogen in case of the high protein corn was 0.64 percent lower than that of the low

protein corn.

By taking the average of the undigested nitrogen for all the pigs during period I and comparing this with the corresponding data for Pigs 1 and 4 in Period II we get a comparison of the undigested nitrogen in Feed A, common corn, with that of Feed C, high protein corn. These results show that the undigested nitrogen for Feed A was 2.274 percent and for Feed C 2.092 percent, or a difference of 0.18 percent. This difference however is not as great as the individual variation between the pigs, consequently the difference in the amount of undigested nitrogen cannot be attributed solely to the difference in the feeds. By making a similar comparison with Pigs 2 and 3, we get the undigested nitrogen of the common corn and the low protein corn. These results are, for common corn, 2.274 percent, and for low protein corn 2.728 percent, or a difference of 0.45 percent. This difference is more than would reasonably be expected to be due to individuality or breed and hence indicates that the feed itself affects the amount undigested in this case.

Having found the amount of corn consumed and the amount of feces excreted, together with the composition of each, there can be determined the coefficient of digestibility of the protein. These data are given in the following table.

Table 9: Digestibility of the Protein in the Three Kinds of Corn.

Pigs. No.	Breed.	Corn Fed	Corn Con- sumed. pounds	Protein Con- sumed. pounds	Protein Undi- gested. pounds	Percent of Pro- tein Di- gested.	Protein Digest- ed. pounds	Digest- ible Protein Con- sumed Daily per 100 W't.	Digestible Protein Consumed Per 100 lbs. Feces.
Period I, June 1st to 8th.									
1.	Tam	A	24.50	2.78	0.30	89.1	2.47	0.123	-----
2.	Dur.	A	24.50	2.78	0.30	88.2	2.17	0.117	-----
3.	Tam.	A	22.26	2.53	0.27	89.3	2.25	0.114	-----
4.	Dur.	A	19.00	2.16	0.24	89.0	1.92	0.113	-----
Ave.									
1&3	Tam.	A	-----	-----	-----	89.2	-----	0.118	-----
Ave.									
2&4	Dur.	A	-----	-----	-----	88.6	-----	0.115	-----
Ave.	All	A	-----	-----	-----	88.9	-----	0.117	-----
Period II, June 15th to 22nd.									
1.	Tam	C	24.50	2.88	0.36	87.5	2.52	0.124	50.04
2.	Dur.	B	19.25	1.96	0.39	80.1	1.56	0.084	39.00
3.	Tam.	B	18.55	1.88	0.29	84.7	1.59	0.082	39.75
4.	Dur.	C	18.39	2.16	0.21	90.4	1.95	0.111	48.75
Ave.	Tam								
1&4	Dur..	C	-----	-----	-----	88.95	-----	0.117	49.39
Ave.	Dur								
2&3	Tam.	B	-----	-----	-----	82.40	-----	0.083	39.37

From the above tables we get the coefficient of digestibility of protein in the three kinds of corn used in this experiment. From Period I we find the digestibility of common corn to be fairly constant with each of the four pigs, being for Pig 1, 89.1 percent; for Pig 2, 88.2 percent; for Pig 3, 89.3 percent; and for Pig 4, 89.0 percent, or an average of 88.9 percent. In period II we have the digestibility of the protein in the high protein and in the low protein corn. The coefficients were as follows: for high protein corn 87.5 and 90.4 for Pigs 1 and 4 respectively, averaging 88.95 percent. For the low protein corn, 80.1 and 84.7 for Pigs 2 and 3 respectively, averaging 82.4 percent. These data show that the high protein corn had 6.55 percent higher coefficient of digestibility than the low protein

No.	Sex	Age	Height	Weight	Temp.	Pulse	Respiration	Blood Pressure	Hemoglobin	Hematocrit	Red Cells	White Cells	Platelets	Reticulocytes	Morphology	Diagnosis
1	M	25	170	65	37.0	72	16	110/70	15	45	4,500,000	10,000	150,000	0.5	Norm.	Norm.
2	F	30	160	55	36.8	68	14	100/60	12	42	4,200,000	8,000	120,000	0.2	Norm.	Norm.
3	M	28	175	70	37.2	75	17	115/75	16	48	4,800,000	12,000	160,000	0.6	Norm.	Norm.
4	F	22	155	50	36.5	65	13	95/55	10	40	4,000,000	7,000	110,000	0.1	Norm.	Norm.
5	M	35	180	75	37.5	78	18	120/80	18	50	5,000,000	14,000	170,000	0.7	Norm.	Norm.
6	F	27	165	60	36.9	70	15	105/65	14	44	4,400,000	9,000	130,000	0.3	Norm.	Norm.
7	M	20	168	62	37.1	73	16	112/72	15	46	4,600,000	11,000	155,000	0.4	Norm.	Norm.
8	F	32	158	52	36.7	67	14	98/58	11	38	3,800,000	6,000	105,000	0.1	Norm.	Norm.
9	M	24	172	68	37.3	76	17	118/78	17	49	4,900,000	13,000	165,000	0.6	Norm.	Norm.
10	F	29	162	58	36.6	69	15	102/62	13	43	4,300,000	8,500	125,000	0.2	Norm.	Norm.
11	M	31	178	72	37.4	77	18	122/82	19	51	5,100,000	15,000	175,000	0.7	Norm.	Norm.
12	F	26	160	56	36.8	70	15	104/64	14	45	4,500,000	9,500	135,000	0.3	Norm.	Norm.
13	M	23	170	64	37.1	74	16	114/74	16	47	4,700,000	11,500	160,000	0.5	Norm.	Norm.
14	F	33	155	51	36.6	66	13	96/56	10	39	3,900,000	6,500	108,000	0.1	Norm.	Norm.
15	M	21	165	61	37.0	71	15	108/68	15	44	4,400,000	10,500	145,000	0.4	Norm.	Norm.
16	F	28	163	59	36.9	69	14	101/61	13	42	4,200,000	8,800	128,000	0.2	Norm.	Norm.
17	M	34	182	76	37.6	79	19	124/84	20	52	5,200,000	16,000	180,000	0.8	Norm.	Norm.
18	F	25	157	53	36.7	68	14	99/59	11	37	3,700,000	5,500	102,000	0.1	Norm.	Norm.
19	M	26	173	69	37.2	75	17	116/76	17	48	4,800,000	12,500	162,000	0.6	Norm.	Norm.
20	F	30	161	57	36.8	70	15	103/63	14	43	4,300,000	9,200	132,000	0.2	Norm.	Norm.

The above table is a summary of the data obtained from the 20 subjects. The subjects were selected from a group of 100 healthy individuals, and the data were collected over a period of 10 days. The subjects were divided into two groups of 10 each, and the data were collected from each group. The data were then analyzed and the results are presented in the table above. The table shows the following data for each subject: No., Sex, Age, Height, Weight, Temp., Pulse, Respiration, Blood Pressure, Hemoglobin, Hematocrit, Red Cells, White Cells, Platelets, Reticulocytes, Morphology, and Diagnosis. The data are presented in a tabular form, and the results are summarized in the table above. The table shows that the data are consistent with the expected results for a healthy individual. The data are presented in a tabular form, and the results are summarized in the table above. The table shows that the data are consistent with the expected results for a healthy individual.

corn. Noting the data still further we find that during Period I, when the common corn was fed, the digestible protein consumed daily per hundred pounds of live weight was practically the same for all the pigs, varying from 0.113 to 0.123 pounds. The average for the Durocs was 0.110, for the Tamworths 0.118, and for the four animals 0.117 pounds.

During Period II there was considerable difference between the pigs on this point. Nos. 1 and 4, fed the high protein corn, consumed on an average of 0.117 pounds of digestible protein daily, while Nos. 2 and 3, which were fed the low protein corn, consumed on an average of only 0.083 pounds.

In this connection it will be of interest to note that the gain in live weight of the pigs during Period II was for Pig 1, 5 pounds, and for Pigs 2, 3, and 4, four pounds each.

These results on the coefficient of digestibility compare favorably with those to which we have already referred. Snyder found the digestibility of protein was 88.9 for corn containing 11.25 percent protein, and Jordan found 86.1 percent for corn with 8.25 percent protein. Dietrich and Grindley's results showed the digestibility of protein was 80.44 percent for corn containing 9.8 percent protein and 78.18 percent for corn with 8.69 percent protein. Michael and Kennedy found that 81.33 percent was the coefficient of digestibility of protein in corn containing 9.29 percent protein. These data are shown more clearly in the following table.

Kind of Corn	Percent of Protein Dry Basis.	Coefficient of Digestibility of Protein.	Investigator	Number of Trials.	Dates
Common	10.03	86.10	Jordan	1	1886
Common	12.74	89.90	Snyder	1	1893
Common	11.34	80.44	Dietrich & Grindley	Ave of 2	1906
Common	10.04	78.18	Dietrich & Grindley	Ave of 2	1907
Common	10.64	81.33	Michael & Kennedy	Ave of 12	1910
Common	12.80	88.90	Writer	Ave of 4	1912
High Protein	13.29	88.95	Writer	Ave of 2	1912
Low Protein	11.55	82.40	Writer	Ave of 2	1912

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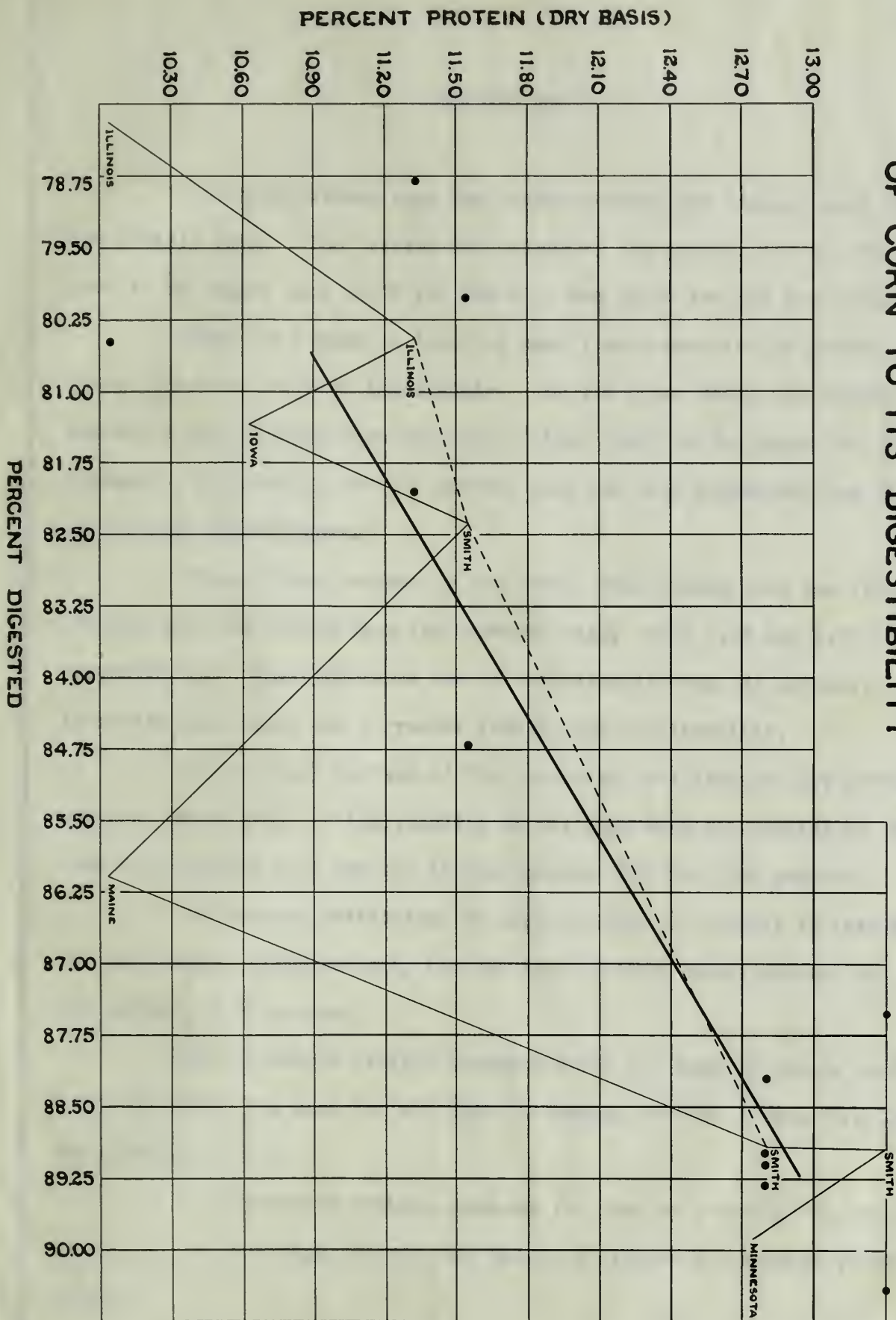
Year	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895	2896	2897	2898	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These data are presented graphically in the following figure . The solid line represents a curve connecting the points determined by taking the average of coefficient of digestibility for the particular corn used. Thus , for the lowest point marked D.G. (Dietrich & Grindley) the average coefficient of digestibility was 78.18 percent and the composition of the corn was 10.04 percent protein. This curve while somewhat irregular shows, if we eliminate the experiment of Jordan, that there is a gradual tendency for the coefficient of digestibility to increase as the percentage of the protein in the corn increases.

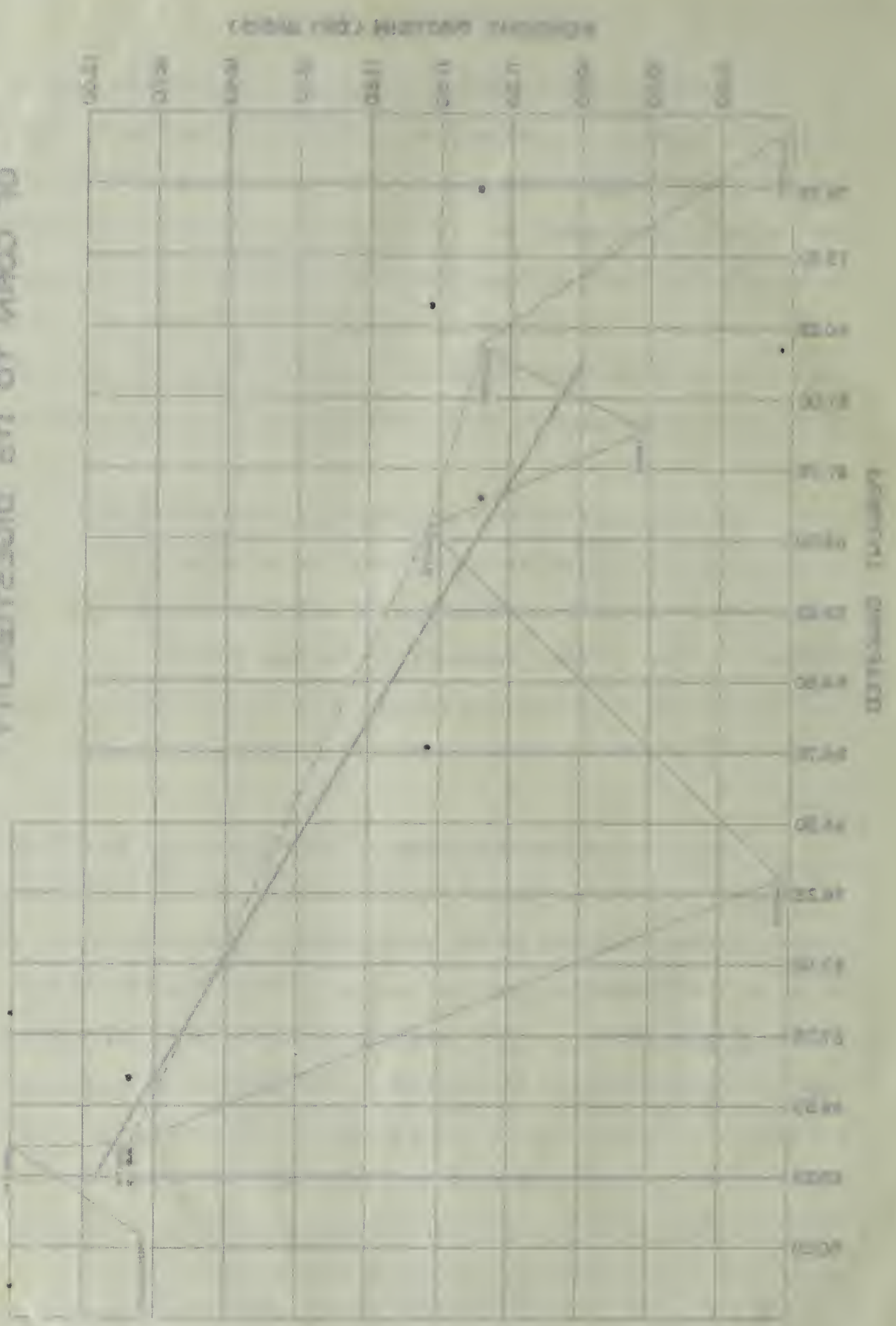
If the work of Michael and Kennedy, in which the method for determining the coefficient of digestibility of protein was different from those methods used by any of the other investigators, be eliminated and the other points connected, we have a curve represented by the dash and dot. This is a fairly straight line and indicates, more clearly, that the coefficient of digestibility varies directly with the protein content of the corn calculated on the dry basis.

Again, if we take the average of the averaged data given by Dietrich and Grindley, Michael and Kennedy, and the writer, for the corn having composition of protein below 11.6 percent and also for the values above 12.7 percent, we obtain the following values: For the low, 10.89 percent protein with a coefficient of digestibility of 80.6 percent, and for the high, 12.94 percent protein with digestibility of 89.2 percent. From these two sets of data we obtain two points, the curve of which is represented by the heavy line. This curve represents the general trend which one might reasonably expect the coefficient of digestibility of protein to take, knowing the percentage composition of the corn. This fact emphasizes the necessity of analyzing the feeds in every experiment in order than one may be able to intelligently interpret the results.

RELATION OF THE PROTEIN CONTENT OF CORN TO ITS DIGESTIBILITY



RELATION OF THE PROTEIN CONTENT OF CORN TO ITS DIESTERILITY



CONCLUSIONS.

The high protein corn had harder kernels but smaller ears than the low protein corn. The percentages values of the protein for the two kinds of corn in dry basis were 13.29 for the high and 11.55 for the low protein.

When the change in feed was made from common to low protein corn these pigs went off feed immediately. On the other hand, the change from common to high protein corn had very little effect on the appetites of the animals. Apparently, the low protein corn was less palatable than the common or the high protein corn.

The nitrogen content of the feces, when common corn was fed, was greater with the Durocs than the Tamworth pigs, being 2.49 and 2.05 percent respectively. The difference due to individuality was .33 percent. This indicates that breed was a greater factor than individuality.

The nitrogen content of the feces when the high and low protein corn were fed, where breed or individuality of the pigs were not considered, varied from 2.73 percent with the low to 2.09 percent for the high protein.

The average coefficient of digestibility of protein in corn was: For the common, 88.90 percent, for the high protein, 88.95 percent and for the low protein 82.40 percent.

The digestible protein consumed daily per hundred pounds live weight was practically the same for all pigs, averaging for the Durocs, 0.110 and for the Tamworths 0.118.

The digestible protein consumed for the low protein corn was 0.083 pounds and for the high protein corn was 0.117 pounds per hundred pounds live weight.

The results in this investigation indicate that in case of swine,

the coefficient of digestibility of the protein in corn varies directly with its protein content. Finally, this study shows that in the interpretation of results of experiments it is of great importance to know the exact composition of the feeds used.

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